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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

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| IN RE APPLICATION OF | : |
| STEPHANE POCAS, ET AL. | : EXAMINER: JONES, E. W. |
| SERIAL NO: 10/584,052 | : |
| FILED: JUNE 22, 2006 | : GROUP ART UNIT: 2892 |
| FOR: METHOD OF SEALING TWO PLATES WITH THE FORMATION OF AN OHMIC CONTACT THERE BETWEEN | : |

REPLY BRIEF UNDER 37 CFR § 41.41

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

Commissioner:

The present Reply Brief is presented in order to point out and respond to numerous errors in the Examiner's Answer (hereinafter EA) as to clearly improper and unreasonable interpretations of the teachings of the references relied on in the rejection of Claims 1-3, 5-17, 19, and 21-23.

## I. The Examiner Takes Contradictory Positions

Appellants note a contradiction in Examiner's position. At page 6, lines 9 – 11 of the EA, according to the Examiner, in Neilson, the metallic implanted species diffuse toward the interface and beyond. However, at pages 39 and 45-49 of the EA, the Examiner declares that the recombination centers are concentrated at an interface between the bonded wafers and absent from the blocking layer. This later position totally contradicts the Examiner's interpretation according to which there is diffusion of the dopants beyond the assembly zone.

### A. Neilson Does not Disclose Diffusion of Dopants Beyond the Interface

In Neilson, a thermal treatment is made:

- After assembling both wafers, but in the case of dislocations (col. 4, l. 32-34), not dopants; and
- Before assembling the substrates, in the case of doping species, to make them diffuse ***in*** the substrate (col.4, l. 47-49).

Another thermal treatment can be made during assembling (see col.5, l. 8-13), but Neilson describes that it is quite low, and does not make the dopants diffuse. A thermal treatment can be performed for a controlled diffusion, or a distribution of the recombination centers in the layer (Neilson's claim 20).

In the prior art commented in Neilson (col.4, l.59-63), a thermal treatment is for making the dopants diffuse within the substrate (« *The metal had to have an appropriately high diffusion rate so that it could diffuse into the wafer in an acceptable time at this temperature* »).

The above shows that in Neilson the thermal treatments in the case of dopants are in general performed before assembly. Treatments after assembly do not induce any diffusion beyond the interface, which the Examiner acknowledges on page 39, l. 15-18, page 45, l. 9-12 or page 49, l. 12 – 16 of the EA: « *...the recombination centers are concentrated at an interface between two bonded wafers and absent from the blocking layer* ».

## II. The Examiner's Response to Arguments is Incorrect

### A. The Examiner Purported Evidence is Irrelevant

At page 22, lines 4 – 9, of the EA, the Examiner refers to four documents, which do not support the outstanding rejection. According to the Examiner, these documents describe different applications, all of them disclosing the formation of Si-alloys at the surface of a Si substrate or inside said substrate. The Examiner is wrong: all four documents describe an implantation in depth.

Only Narayan describes some effect at the surface. The Examiner cites (p.21 of the examiner's answer) numerical values taken from col. 11 and 12 (example 4). This example 4 concerns an implantation of Cu ions which, after laser annealing of the substrate, are located in a zone comprised between the surface and a depth of 20 nm (see col. 12, l. 14-15), but which have not formed any alloy with silicon. Furthermore this result is obtained by laser annealing, the laser having specific characteristics, in order to make the material fuse and become liquid, which is certainly not within the scope of Appellants' invention.

None of the cited documents, except Ommen (col.2, l. 18; at a depth of – 200 nm) discloses forming silicides.

**B. Neilson Does not Disclose the Claimed Dosing**

Page 22, lines 10 – 18, of the EA states :

> *NEILSON does not contain any limitation or restriction which would preclude applying its teaching to doses of the order of those claimed, namely $10^{16}/cm^2$. This, in combination with the new cited documents, discloses the formation of recombination centres in Si substrates, comprising Co, Ni, Ti, Cu or Pt, with doses up to $2,6x10^{16}/cm^2$, at which silicide can be formed, as well as recombination centres, and this is the evidence that the formation of recombination centres, at such a dose, would not destroy the operations of the NEILSON device.*

This is also wrong. Nielson's silence does not necessarily mean that there are no restrictions or limitations regarding dosing. This position of the Examiner is completely unsupported. Neilson does not disclose any dosing that would result in the formation of a silicide and still maintain the purpose of Neilson.

At page 28, l. 6 to l. 16, of the EA, the examiner tries to equate the doping concentration $10^{19}$ $cm^{-3}$ to a dose of $10^{14}$ $cm^{-2}$. The Examiner fails to provide any explanation for this purported equivalence. At pages 7-8 of the Appeal Brief, Appellants provide an analysis regarding concentrations indicated at col. 4, l. 51 of Neilson. Appellants want to

make clear that Neilson does not disclose any dosing. Appellants estimate is merely for the purpose of showing that any dose in Neilson must have been very low, and not for disclosing any exact value which would be implicit from Neilson. Appellants estimate of Neilson ($10^{14}$ $cm^{-2}$, which the Examiner does not dispute), is drastically different from the claimed value of $10^{16}$ $cm^{-2}$.

Further, Neilson does not teach that one could go beyond the maximum value indicated. The concentration can vary in the disclosed range (see col. 4, lines 50-51 of Neilson), not beyond, and makes the required speed vary accordingly. However, there is no disclosure of any value or any effect outside this range.

One cannot conclude, as the Examiner does on page 28, lines 15-16, that Neilson can be modified such that its recombination centers also act/function as an ohmic contact. Recombination centers are diluted in the material (and occupy interstitial sites as explained in subparagraph D below), and an ohmic contact results from a concentration of the implanted species (as explained in Appellants' claim 27 there is a diffusion of the species towards the interface between the first substrate and the second substrate) and from the reaction which forms an alloy between the implanted species and the semi-conductor material.

**C. There is no Diffusion in Neilson Beyond the Interface**

At page 28, l.18 to page 29, l. 7 of the EA, the examiner uses temperature to argue that the implanted species diffuse both upwards and downwards, across the interface. But in Neilson, ***the contrary happens***. As stated on col. 4, l. 47 – 49, of Neilson, the temperature results in a diffusion of the dopants from the surface, towards the inside of the substrate, to create layer 24. Also, at col. 4, lines 59-63, reference is made to Neilson's prior art technique, in which it is heated up to 800-900°C, after metal has been evaporated on the surface. This results in a penetration of the metallic species inside the substrate. It is

therefore not possible to conclude, as the Examiner does, that, when the three main documents are combined, the scope of Neilson remains unchanged.

**D. There is No Ohmic Contact In Neilson**

As explained at page 10 of the Appeal Brief, there is no formation of a metallic ohmic contact as claimed. The selection of a dopant in Neilson is based on energy levels and not its ability to react with the substrate.

Examining Neilson's file history provides additional evidence supporting Appellants position. During Neilson's prosecution, Neilson submitted arguments in response to an Office Action (a copy of which is submitted herein) regarding the dopants of Neilson. This attached Office Action response, at page 2, 4 lines from bottom down to page 3, l.6, states:

> to reduce minority carrier lifetime by controlling the density, it is ***necessary*** that the dopant has an ***energy level near the center of the forbidden energy band*** of the ½ conductor. ***Such dopants have little or no effect on conductivity*** but because of their mid band energy levels, they provide recombination centers. The elements that have energy levels useful as recombination centers generaly ***occupy interstitial sites in the crystal*** rather than the substitutional sites occupied by the P and N type dopants used to control conductivity.

In other words, these statements made during the prosecution of Neilson support Appellants' argument regarding the important role played by the energy levels of Neilson.

Further, these arguments from Neilson's file history are evidence that the recombination centers occupy interstitial sites in the crystal. Should they migrate towards the interface and react with silicon, as the Examiner assumes, then they would leave their sites and loose their role as recombination centers.

Further, as these **dopants have little or no effect on conductivity, they therefore cannot be involved in the process of forming an ohmic contact which, by definition must conduct.**

### E. Kakumu and Yamamoto do not Cure the Deficiencies in Nielson

At pages 22-23 of the EA, the Examiner combines Kakumu and Yamamoto with Neilson which, according to him, would disclose a thermal treatment of at least 800°C. The Examiner's assertions are again wrong because the temperature of 800°C, col. 4, lines 62-63 of Neilson concerns what Neilson considered to be prior art. The passage from which this sentence is taken explains that the Neilson invention does not require what was previously used in the prior art, namely the evaporation of a heavy metal on the surface of the substrate, which was then treated at 800 - 900° in order the make the metal migrate into the material. This method, Neilson says, was applicable only to Au, Pt (see Neilson, col. 4, last line to col. 5, line 1), the other metals not permitting such a treatment (col. 4, lines 4-5). Among these metals are:

- Co, used in VAN OMMEN,
- Boron (B), phosphorus or Cu, in NARAYAN;
- Co, Ni, Er, as in OOSTRA.

Only FRANCIS describes Au and Pt (see paragraph [0051]), but the method implemented (diffusion from the back surface of the substrate) results in a very deep implantation (see above), the depth being such that it is highly incompatible with the teachings of Neilson and with the conditions set in the present application to make an ohmic contact at the surface, or at the interface of both substrates.

At page 23, l.10 to page 24, l.2 of the EA, According to the Examiner, Kakumu, Yamamoto and Neilson disclose the formation of a metal – Si layer at at least 400°, at doses substantialy identical to those of Neilson (he refers to « $10^{14}\,cm^{-2}$ »). As discussed above, Neilson does not disclose $10^{14}\,cm^{-2}$ as a dose, and this estimate is drastically different from the value recited in Appellants' claims.

Neilson only describes a concentration between $10^{14}$ $cm^{-3}$ and $10^{19}$ $cm^{-3}$. The doses in the other two documents (Kakumu (col. 3, l. 33) and Yamamoto (col. 5, l. 50)) are, at least, one order higher than Appellant's estimate for Neilson. Therefore one cannot say that all three documents (Kakumu, Yamamoto and Neilson) teach similar results or that all there documents (see page 23 of the EA) concern substantially identical structures obtained by a process substantially identical to the one disclosed and claimed in the present application.

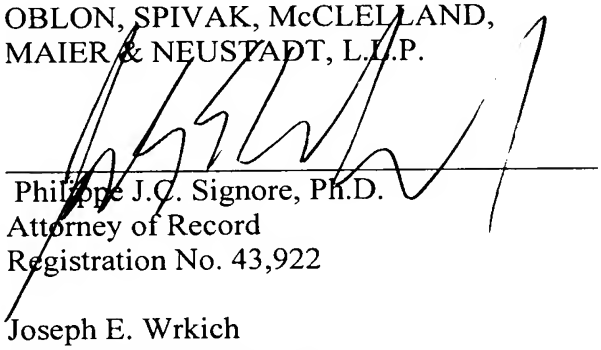
At page 24, l.3 – 13, of the EA, the Examiner states that one could use the recombination centers of Neilson as ohmic contact since Neilson, Yamamoto and Kakumu describe variations which affect the performance of the structure of the final device. These different documents do not teach process variations, but have very different teachings (at least concerning Neilson, on the one hand, and Yamamoto and Kakumu, on the other hand).

## III. CONCLUSION

In light of the above-noted errors, the reversal of all applied grounds of rejection is respectfully submitted to be in order and respectfully requested.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, L.L.P.



Philippe J.C. Signore, Ph.D.
Attorney of Record
Registration No. 43,922

Joseph E. Wrkich
Registration No. 53,796

Customer Number
22850

Tel: (703) 413-3000
Fax: (703) 413 -2220
(OSMMN 07/09)

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Patent Application of Neilson

Serial No.: 08/885,878



Art Unit: 2822

Filed: June 30, 1997

Examiner: K. Picardat

8/B
G. Stanley
9-28-99

Title: IMPROVED LIFETIME CONTROL FOR SEMICONDUCTOR DEVICES



**AMENDMENT**

The Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Responsive to the Office Action dated July 2, 1999, please amend the subject application as follows:

In the Specification:

Page 8, line 25, before "~~either~~", delete "the".

Page 9, line 18, after "Au", change "PT, PD, AG" to --Pt, Pd, Ag--.

In the Claims:

15. (Amended) The method of Claim 6, wherein a dopant for the doping step is one of Au, Pt, Pd, Ag, [PT, PD, AG,] Cu, Fe, Ni, and Co.

Please cancel the Claims 27-33 in Group II without prejudice.

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B

## REMARKS

§112 Rejections

The noted informalities have been obviated by amendment.

§102 Rejections

Claims 1, 6-20, and 24-26 are rejected under 35 U.S.C. §102(e) as being anticipated by Tu, et al. ("Tu"). Reconsideration and withdrawal of the rejection is solicited.

Claim 1 is directed to a method of controlling the minority carrier lifetime in a semiconductor, which includes the step of "**controlling the density of recombination centers** at a wafer-to-wafer bonding interface" (emphasis added). Tu discloses the use of P or N-type dopants to affect the conductivity of the substrates into which the dopants are being implanted, and there is no teaching that this use of dopants results in controlling the density of recombination centers. In fact, the dopants disclosed by Tu are not suitable for this purpose. The P and N-type dopants disclosed in Tu have energy levels near the *edges* of the forbidden-energy band, with P-type dopants having an energy level near the valance-band edge, and N-type dopants have an energy level near the conduction-band edge. To reduce minority carrier lifetime by controlling the density of recombination centers, it is necessary that the dopant has an energy level near the *center* of the forbidden-energy band of the semiconductor. Such dopants have little or no effect on conductivity, but because of their mid-band energy levels, they provide recombination

centers. The elements that have energy levels which make the elements useful as recombination centers generally occupy interstitial sites in the crystal rather than the substitutional sites occupied by P and N-type dopants used to control conductivity. Because the type of dopants used in Tu are not of the type useful in generating recombination centers, the doping steps disclosed in Tu do not result in the control of the density of recombination centers.

Since Tu does not disclose control of recombination centers, Claim 1 must be allowed and Claims 6-20 should be allowed therewith without recourse to the additional patentable limitations respectively recited.

Similarly, independent Claim 24 is directed to a method of controlling the minority carrier lifetime, and includes the step of "selectively doping at least one of the bonding surfaces of the two wafers **to control a density of recombination centers**" (emphasis added). Claims 25 and 26 should be allowed with Claim 24 without recourse to the additional patentable limitations respectively recited.

§103 Rejections

Claims 1-26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Tu in view of Kish, Jr., et al. ("Kish"). However, *prima facie* obviousness is established only when the combined prior art references "teach or suggest **all the claim limitations.**" (MPEP §2142, emphasis added).

There is no basis for an obviousness rejection because the cited prior art references do not teach or suggest all the limitations of Claims 1-26.

As discussed above, Tu does not disclose a method of controlling the density of recombination centers. Since Kish does not teach or suggest selective doping techniques for this purpose, Kish does not remedy the fundamental deficiency of Tu and the rejection cannot stand.

Further, Kish is concerned only with compound as contrasted with elemental semiconductors. Kish teaches on-axis bonding rather than off-axis bonding, and thus teaches away from the present invention. Accordingly, reconsideration and withdrawal of the §103(a) rejection is solicited.

Respectfully submitted,

By: _____

L. Lawton Rogers, III
Reg. No. 24,302
D. Joseph English
Reg. No. 42,514

510 King Street, Suite 400
Alexandria, Virginia 22314
Telephone: (703) 836-0400
Telecopier: (703) 836-1539

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